Adult2child: Motion Style Transfer using CycleGANs

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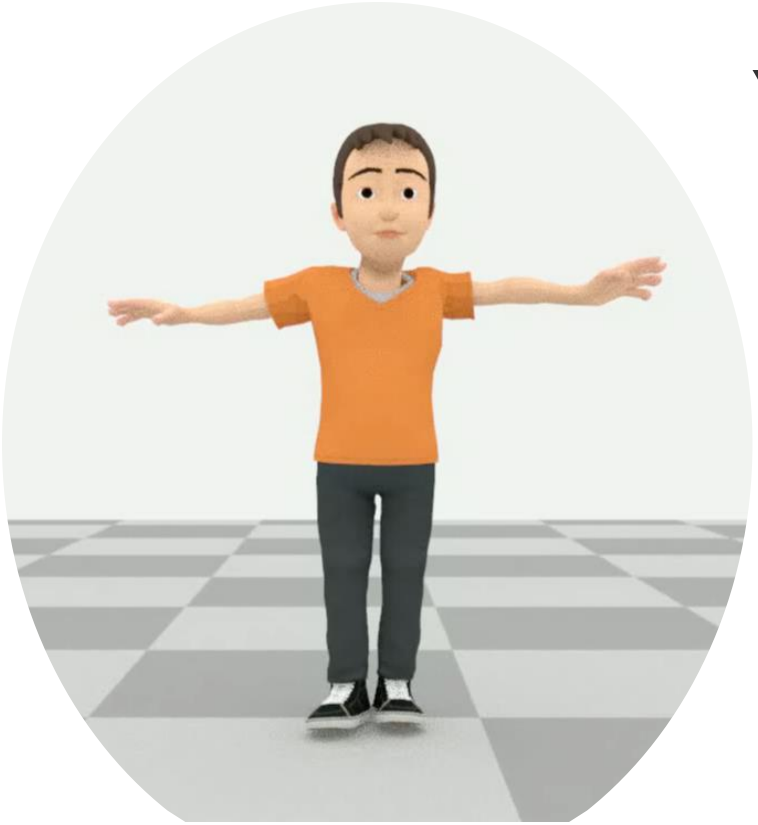
Motivation

- Child characters have gained popularity in the animation and gaming industries.
- Most of the work focused on creating adult motions, but very few for child motions.

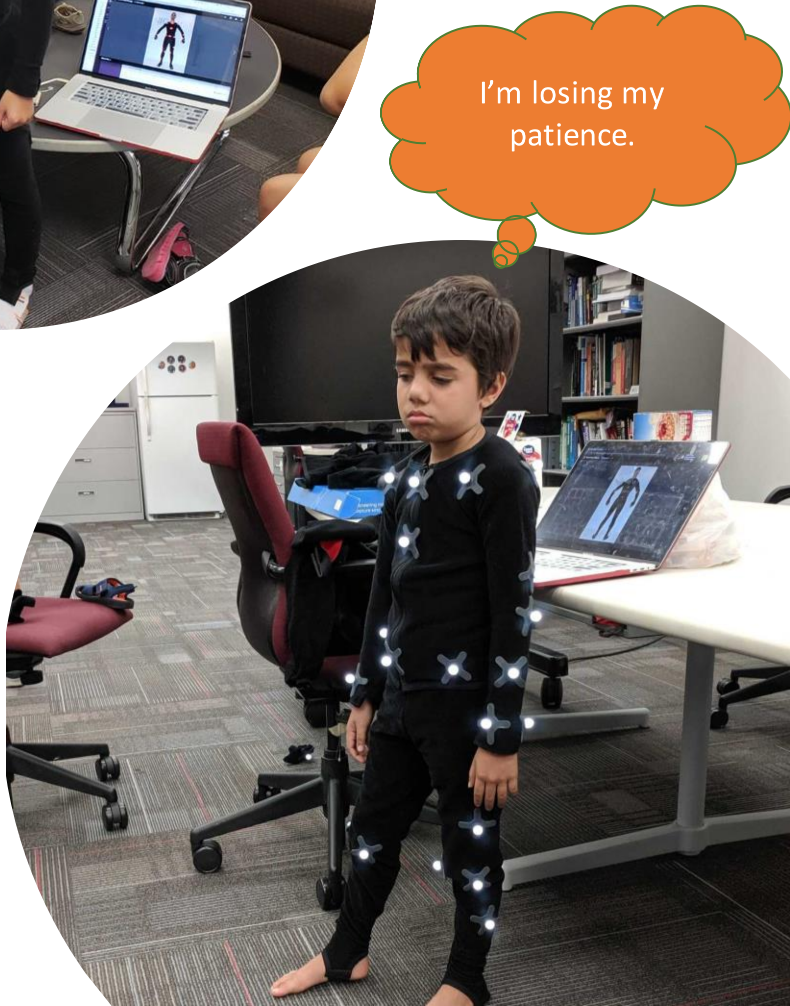


Russell from movie “Up”

Bonnie from “Toy Story 4”

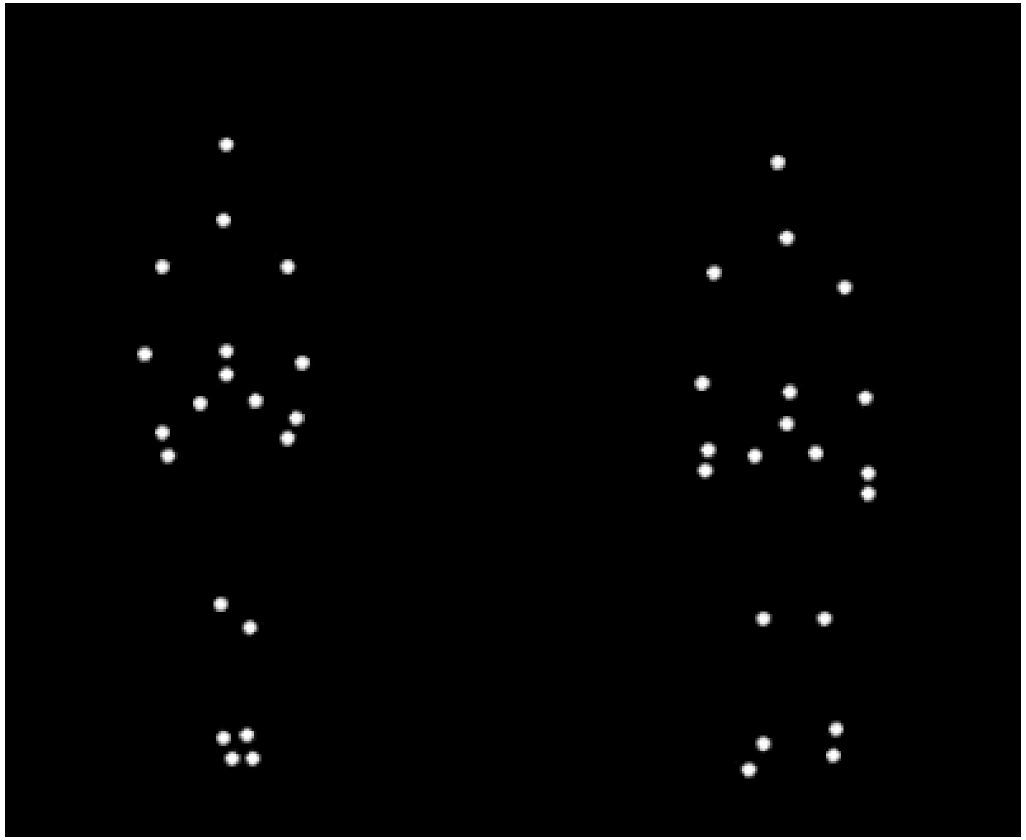
Challenges

- Difficulties of motion capturing children
  - Lack of patience
  - Easily distracted
  - Hard to follow instructions



Challenges

- Given the difficulties of motion capturing children, can we just use adult mocap data on child characters?
- Can we convince the viewers that the motions are from children?
- Jain et al[2016] found that viewers can differentiate child motion from adult motion by viewing point light display videos.



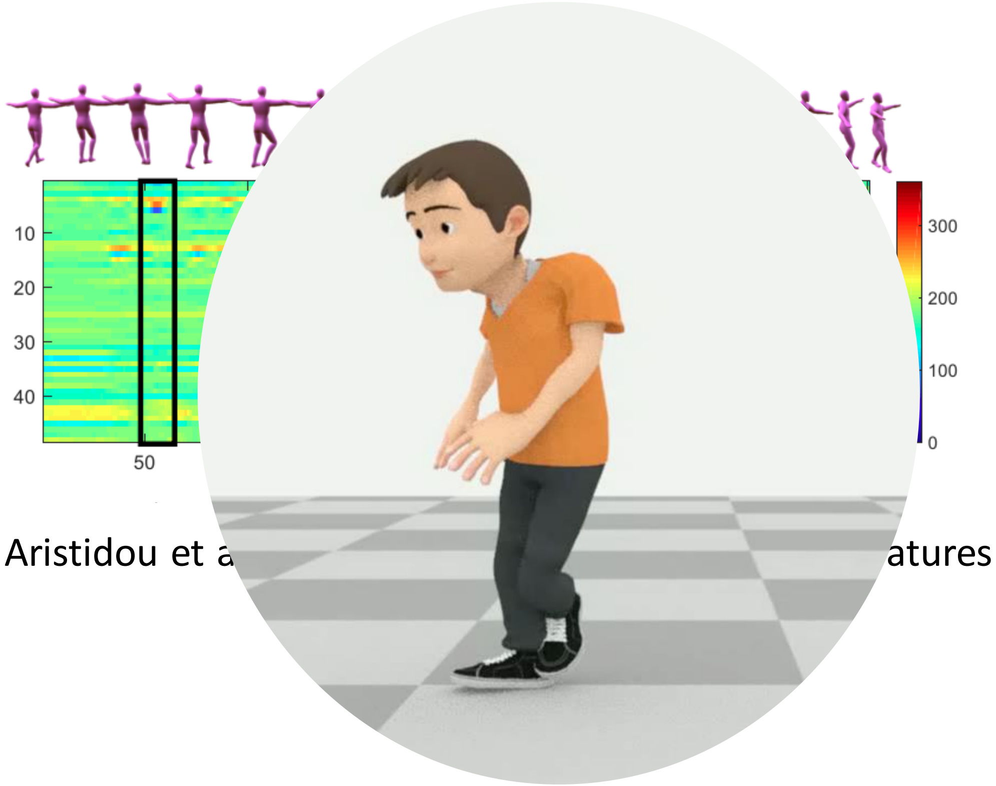
Key Ideas

- Adapt adult motions to child motions that captures both the postures and the timing of child motions.
- Achieve this goal without temporally aligned data given that adult motions and child motions can be drastically different.

Contributions

- **Architecture:**
  - First to adapt cycleGAN for motion style transfer that can alter timing.
  - Redesigned the generators and the discriminators. No temporal alignment.
  - Additional loss terms to output natural and smooth motions.
- **Representation:**
  - Espouse joint angles as an animation-centric representation. Facilitate character binding and skinning.
  - Motion words to encode temporal/spatial information.
- **Dataset:**

  Released a high-quality optical mocap dataset of children.



Aristidou et a… …atures

Related work

Zhu et al.[2017][1]

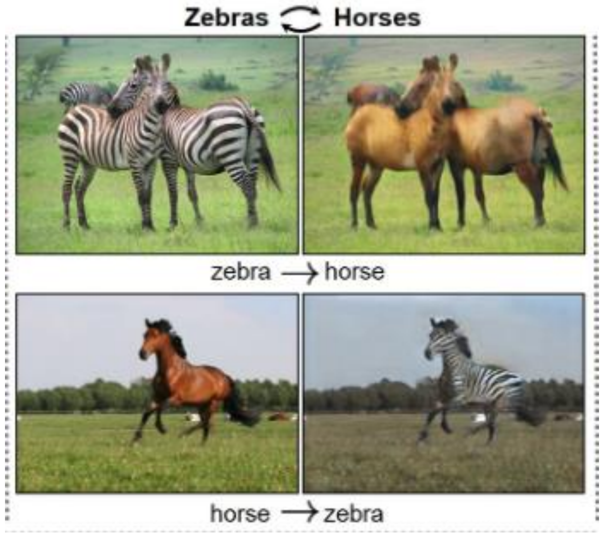
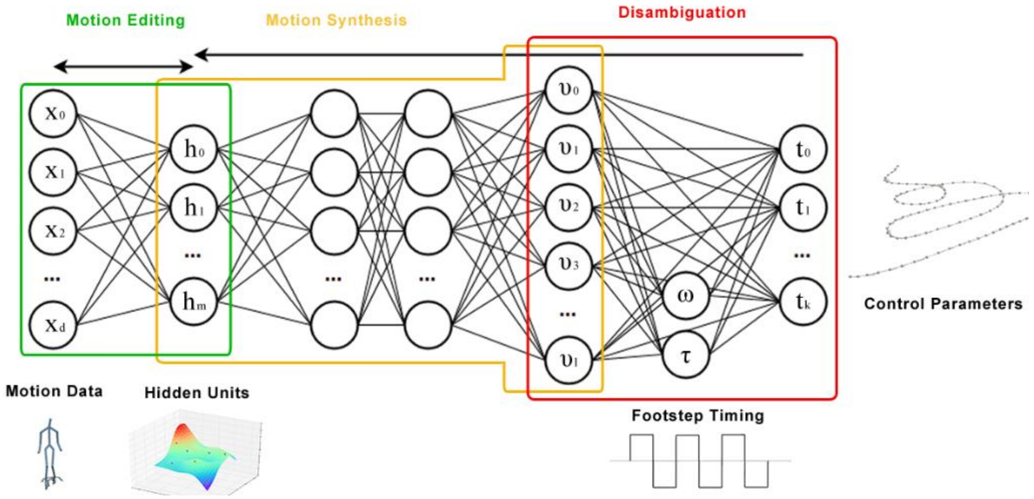


Image style transfer with unpaired training data

Holden et al.[2016][2]



Learn motion manifold from a large dataset(six millions frames)

Aberman et al.[2020][3]

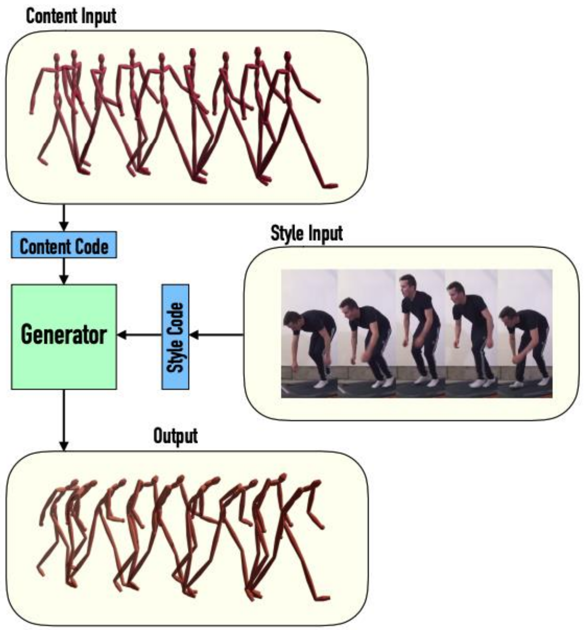
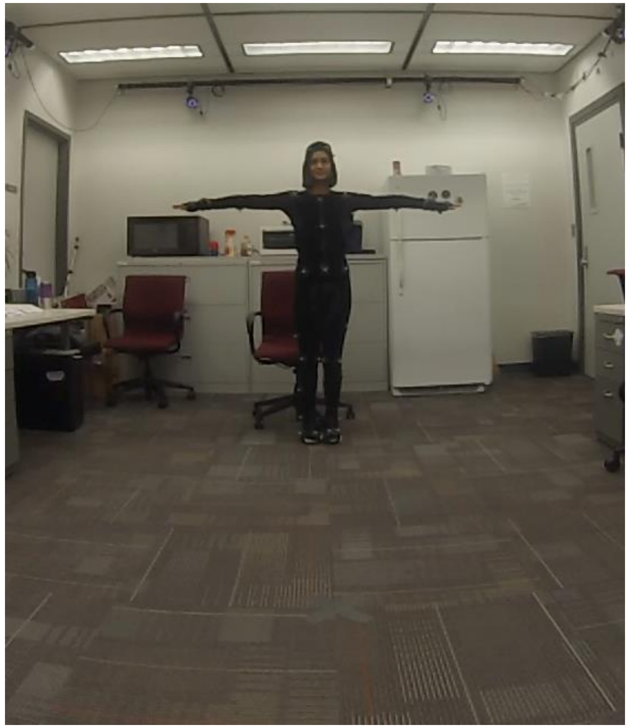


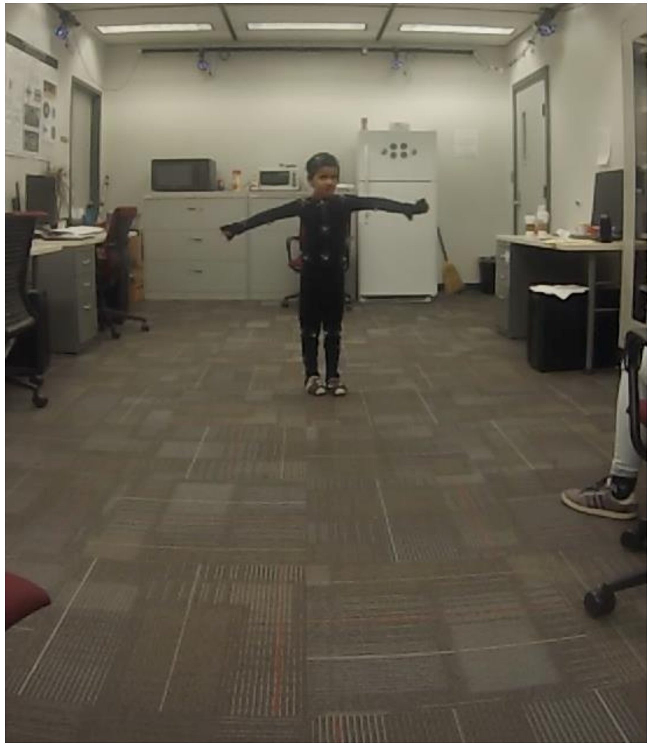
Image style transfer with unpaired training data

[1]Zhu, Jun-Yan, et al. "Unpaired image-to-image translation using cycle-consistent adversarial networks." *Proceedings of the IEEE international conference on computer vision*. 2017.
[2] Holden, Daniel, Jun Saito, and Taku Komura. "A deep learning framework for character motion synthesis and editing." *ACM Transactions on Graphics (TOG)* 35.4 (2016): 1-11.
[3] Aberman, K., Weng, Y., Lischinski, D., Cohen-Or, D., & Chen, B. (2020). Unpaired Motion Style Transfer from Video to Animation. *arXiv preprint arXiv:2005.05751*.

Our Novel Child Dataset: Kinder-Gator 2.0

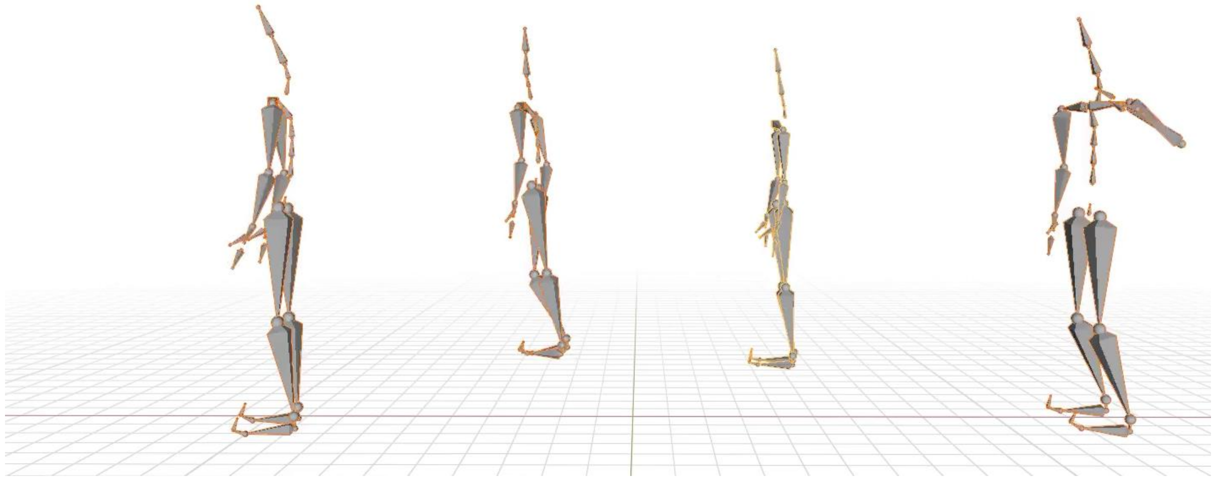
- 8 children (5-10 years old). 9 adults: (18 years old and above).
- ``Jumping jacks”, ``Throw a ball", ``Walk", ``Walk as fast as you can", ``Hop scotch", ``Punch", ``Kick", ``Jog", ``Run as fast as you can”, etc.
- 2-3 repetitions for each action type.



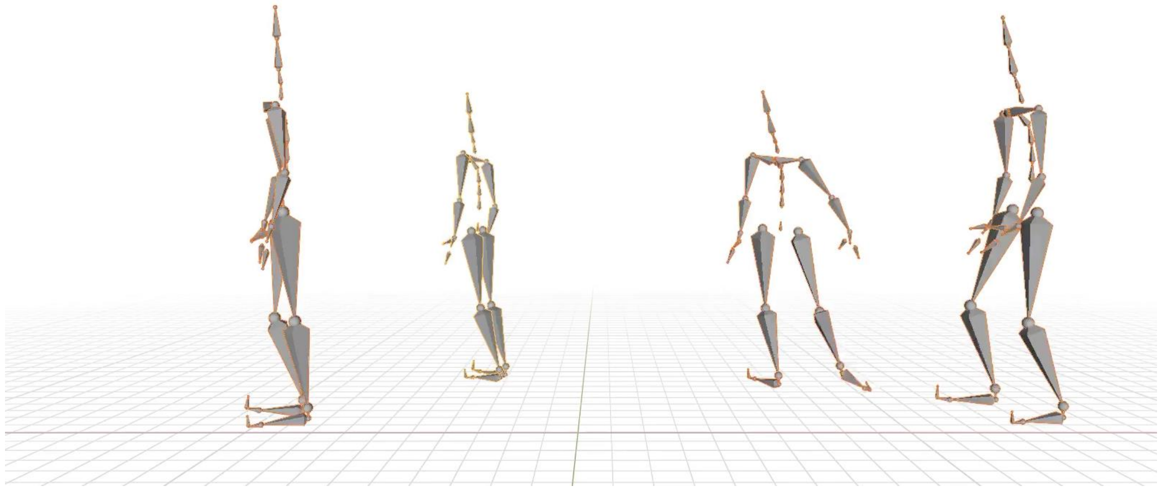


Examples from Kinder-Gator 2.0

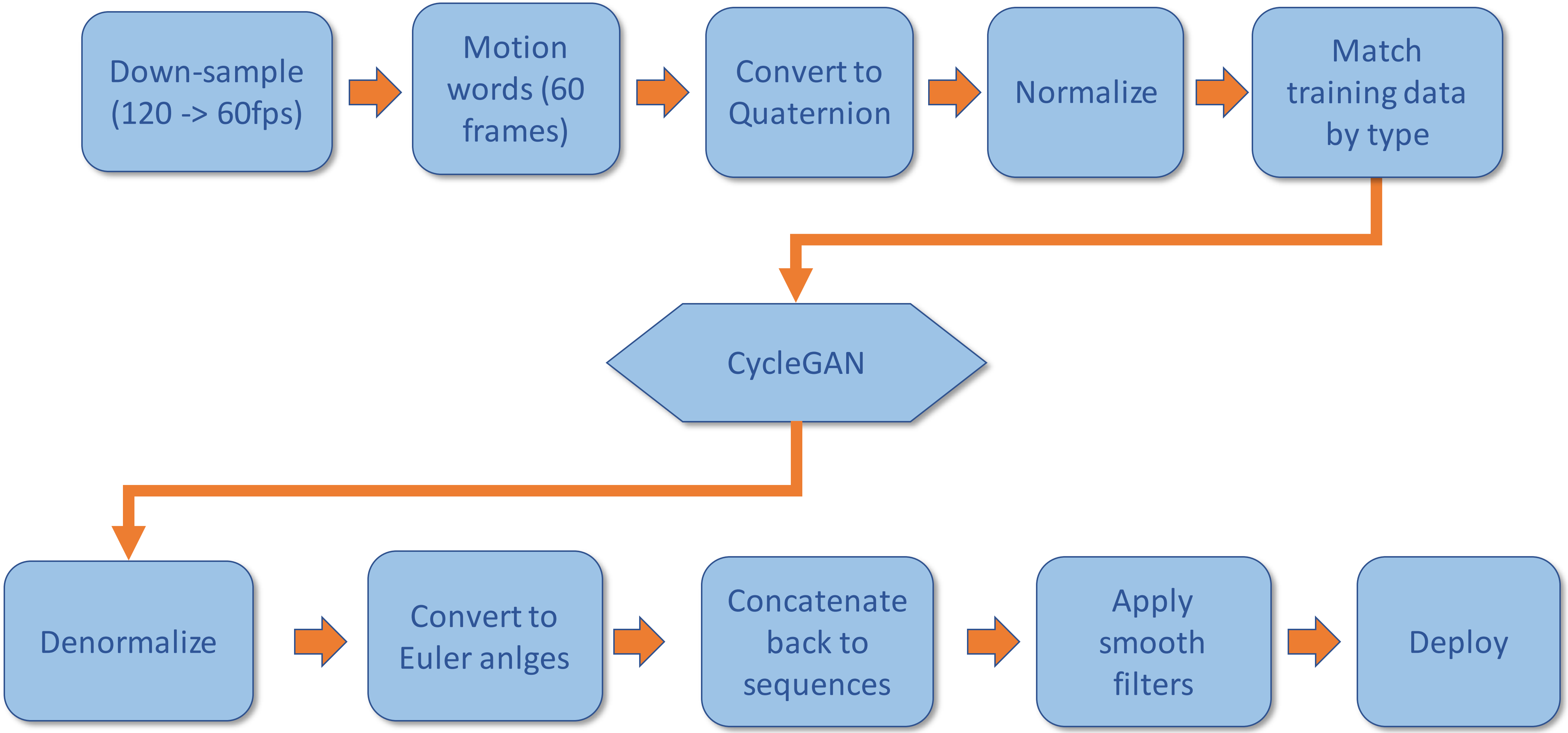
Adult



Child



Pipeline


Down-sample (120 -> 60fps)
Motion words (60 frames)
Convert to Quaternion
Normalize
Match training data by type
CycleGAN
Denormalize
Convert to Euler anlges
Concatenate back to sequences
Apply smooth filters
Deploy

Overall Architecture

Adversarial loss

$$\mathcal{L}_{G_{c2a}} = 0.5 * \mathbb{E}_{c \sim p(c)} [D_a(G_{c2a}(c)) - 1]$$
$$\mathcal{L}_{G_{a2c}} = 0.5 * \mathbb{E}_{a \sim p(a)} [D_c(G_{a2c}(a)) - 1]$$

Cycle loss

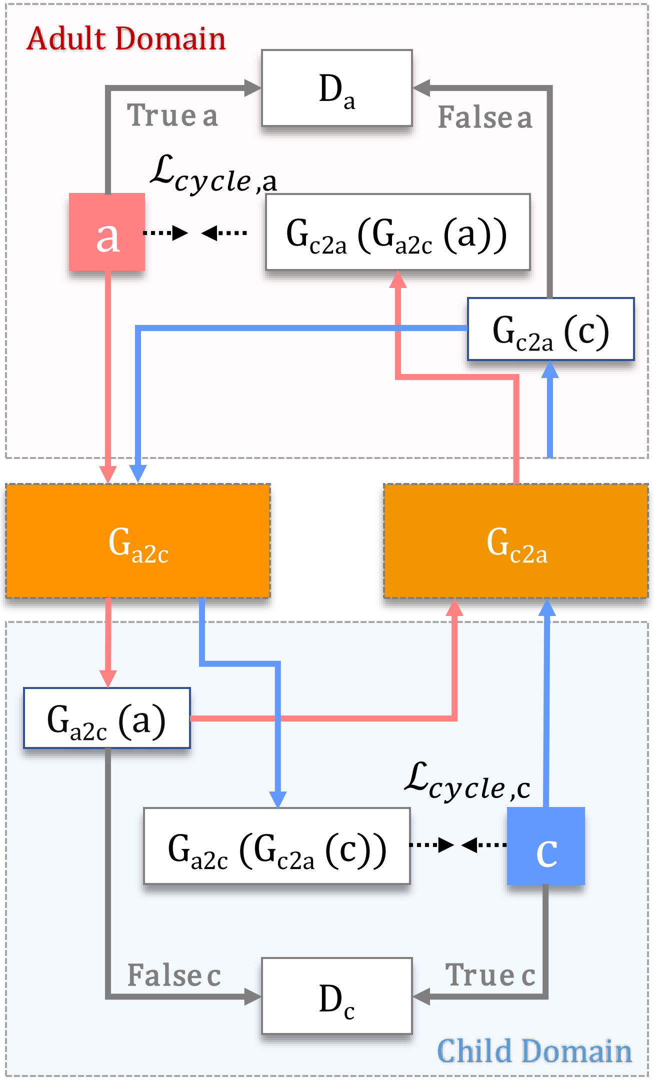
$$\mathcal{L}_{cycle,c} = G_{a2c}(G_{c2a}(c)) - c$$
$$\mathcal{L}_{cycle,a} = G_{c2a}(G_{a2c}(a)) - a$$

Coherence loss

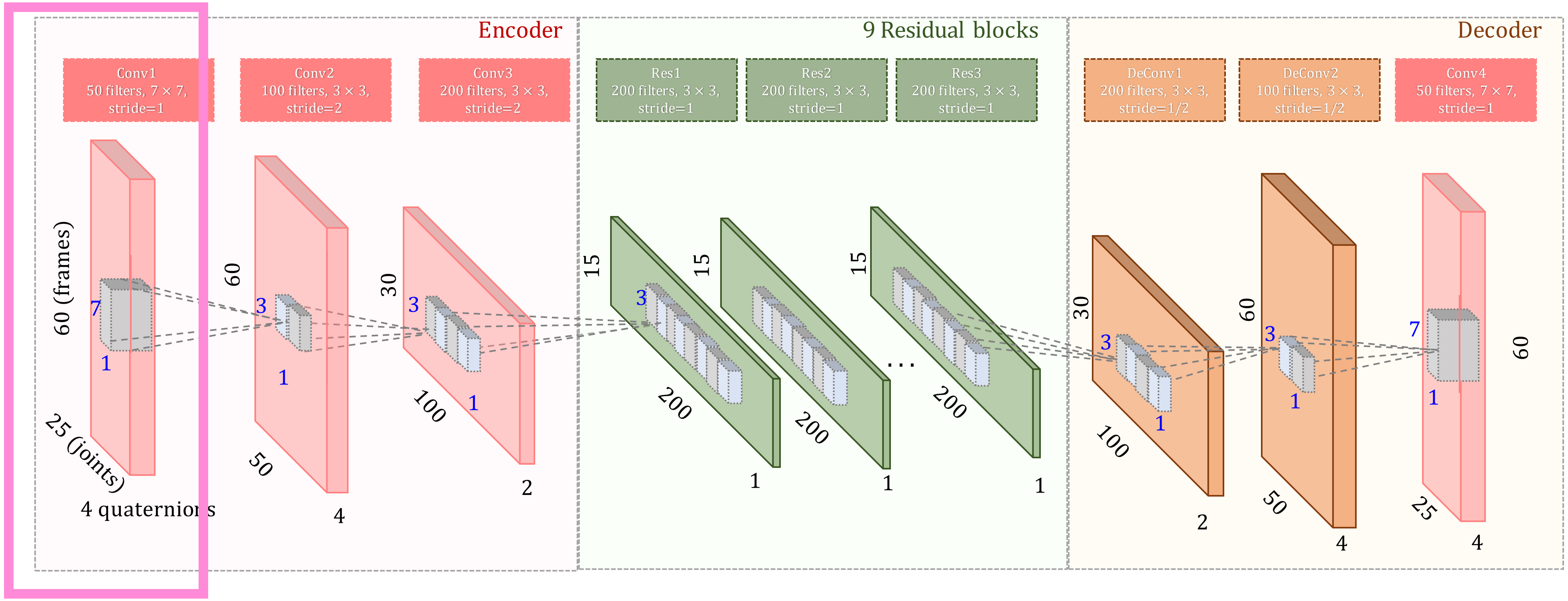
$$\mathcal{L}_{coherence,a} = \sum_t \sum_{DOF} ||G_{a2c}(a)(t) - G_{a2c}(a)(t-1)||$$
$$\mathcal{L}_{coherence,c} = \sum_t \sum_{DOF} ||G_{c2a}(c)(t) - G_{c2a}(c)(t-1)||$$

Transition loss

$$y = G_{c2a}(c)$$
$$\mathcal{L}_{transition,c} = \sum_t \sum_{DOF} ||y_i(t_{overlap:end}) - y_{i+1}(0 : t_{overlap})||$$



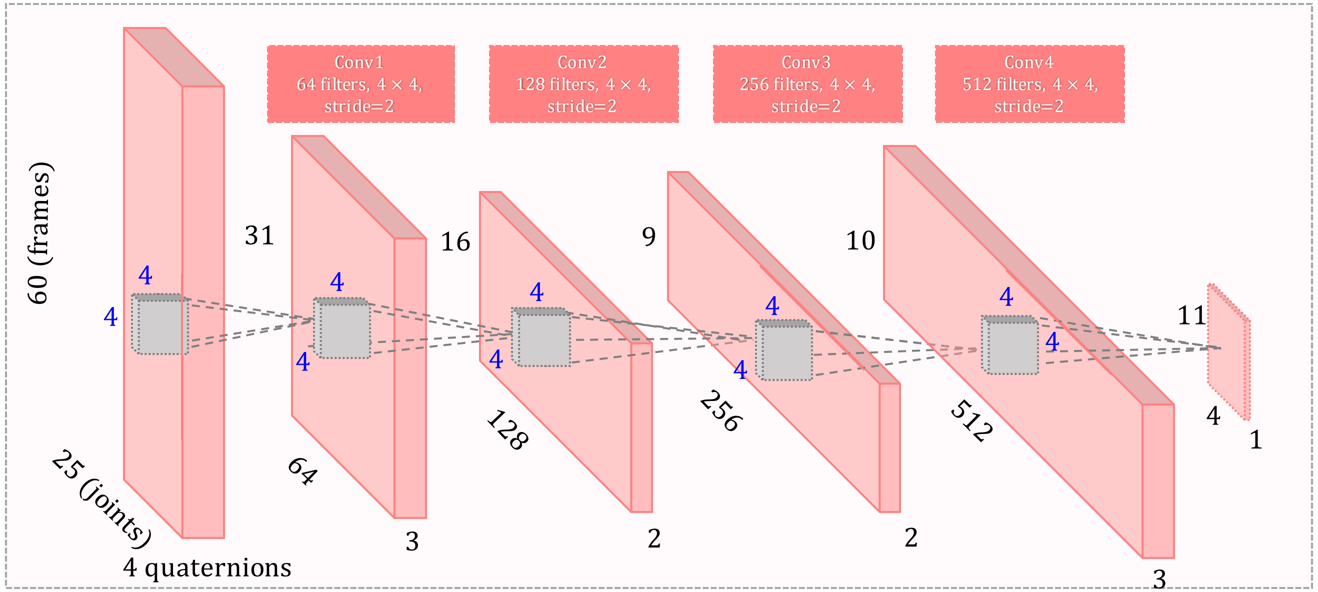
Generator's Architecture



Convolution convolves along the quaternion axis and the temporal axis

Discriminator’s Architecture

Patch GANs

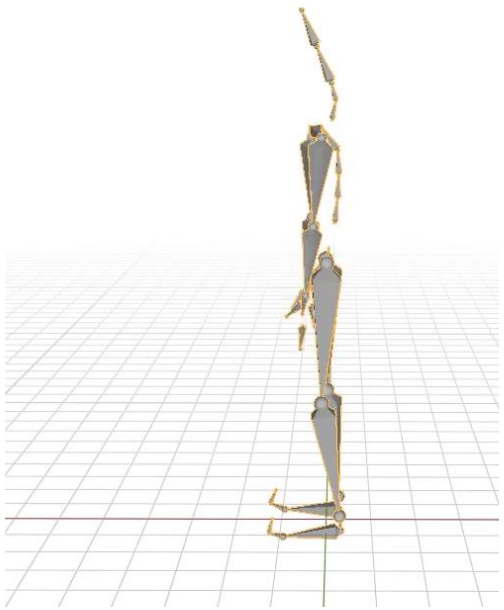


Implementation Details

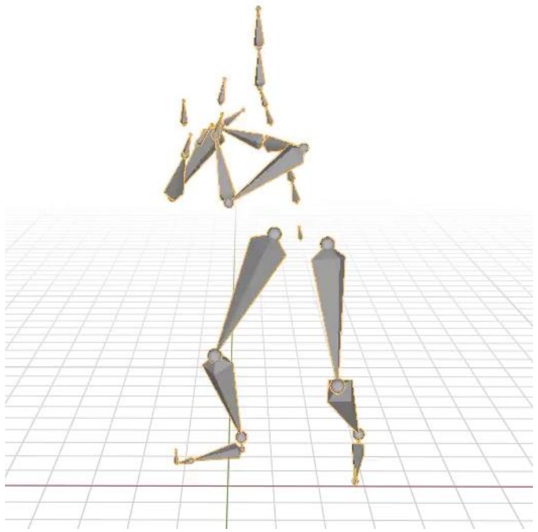
- We implemented and trained the model on Google Colab Pro with P100 or T4 graphics card.
- The model was written in Python using TensorFlow library.
- We trained the model for 180 epochs and the training takes ~7 hours.
- The trained model is 8.67MB.

Our Results: Punch

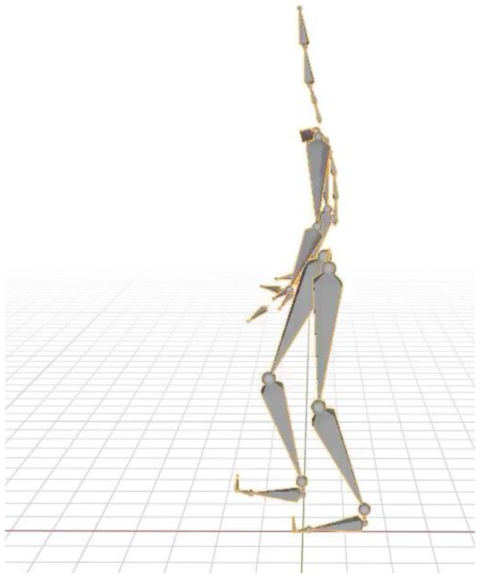
Input adult



Ours

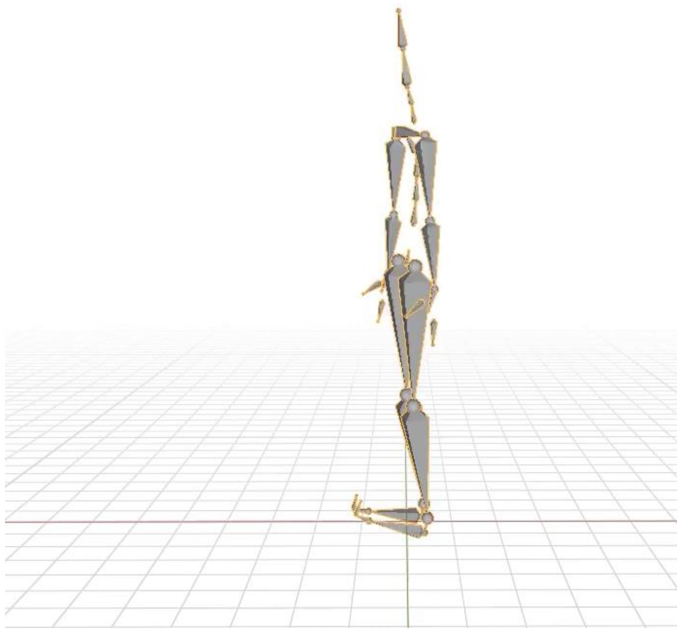


Reference child

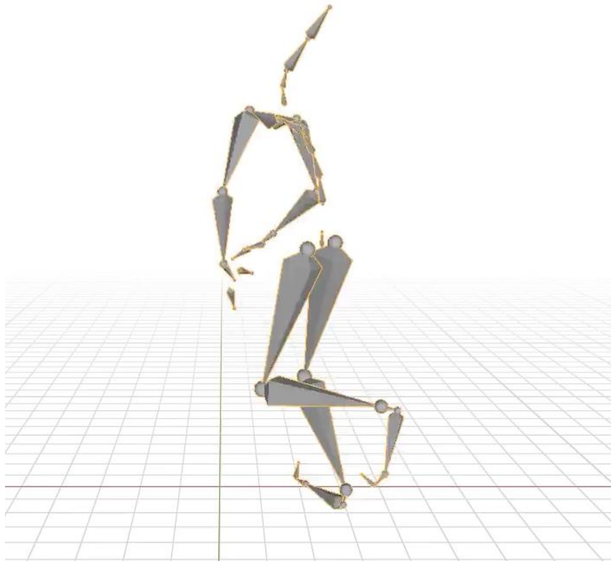


Our Results: Run as fast as you can

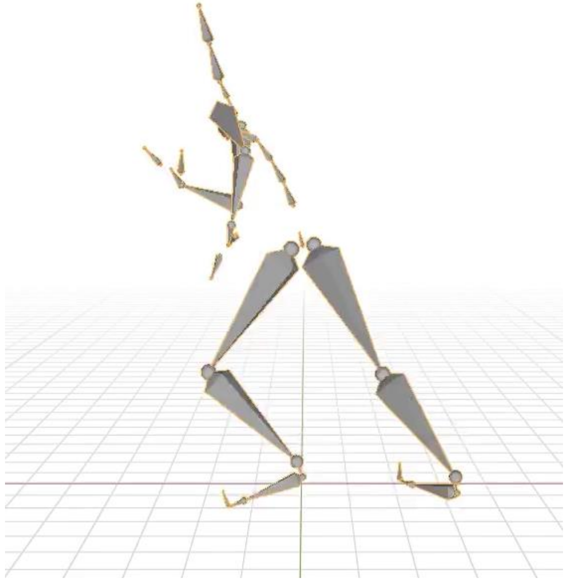
Input adult



Ours

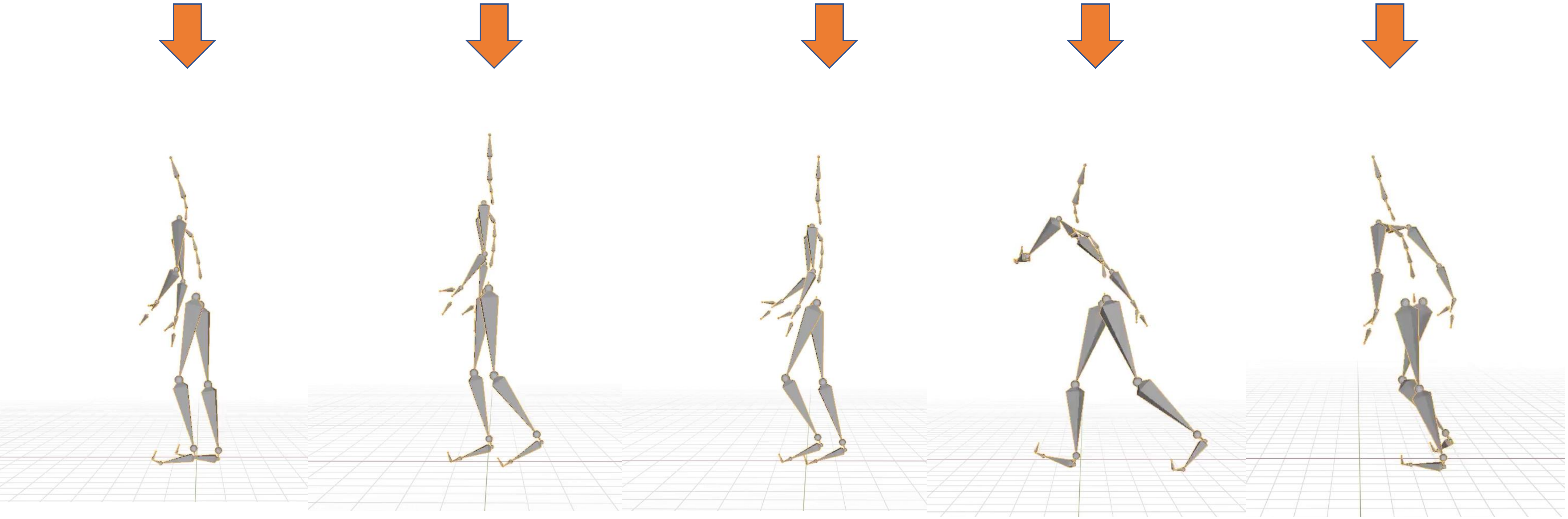


Reference child



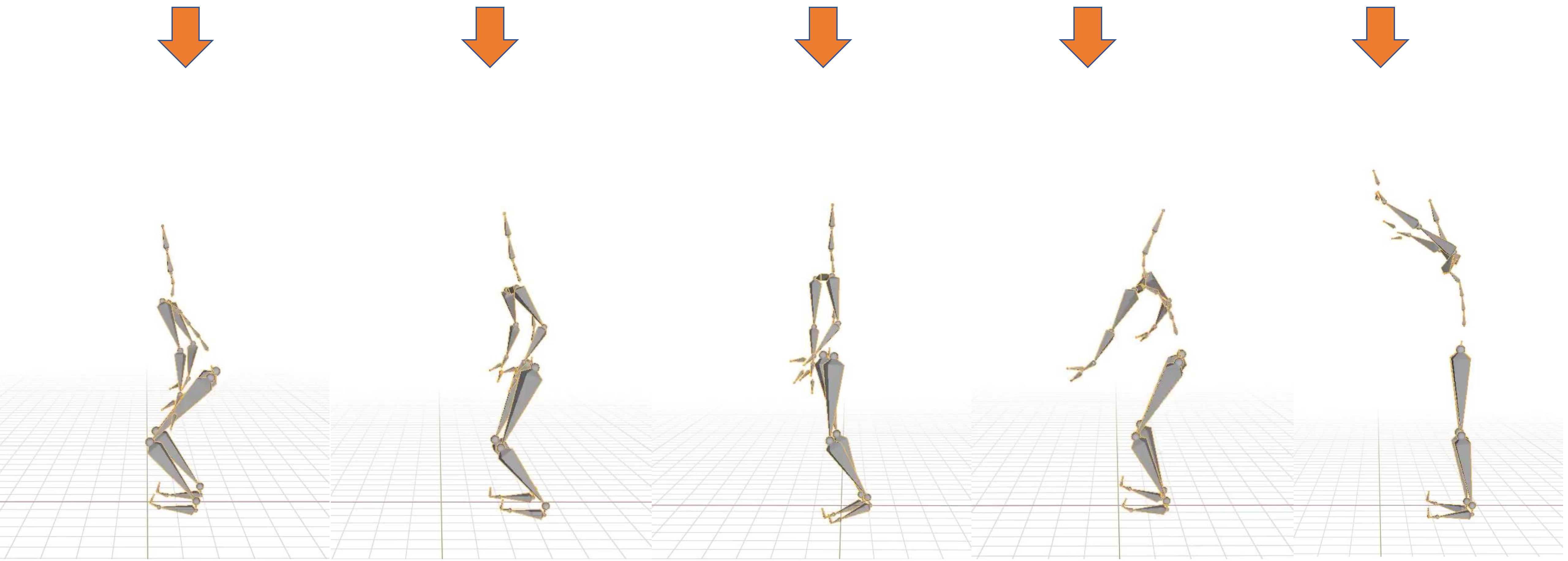
Compare with state-of-the-art: Walk as fast as you can

Input adult | Holden et al[2016] | Aberman et al[2020] | Ours | Reference child



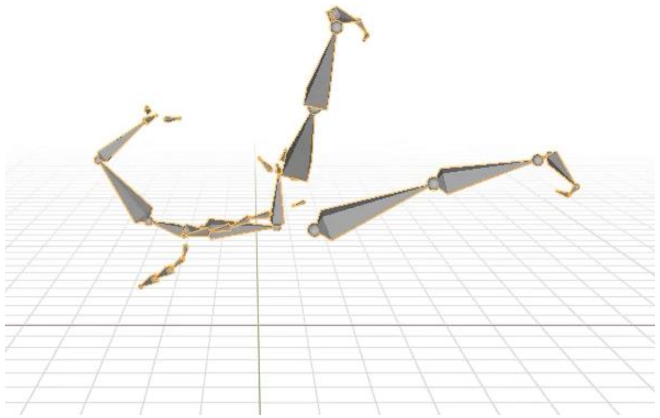
Compare with state-of-the-art: Jump as high as you can

Input adult | Holden et al[2016] | Aberman et al[2020] | Ours | Reference child

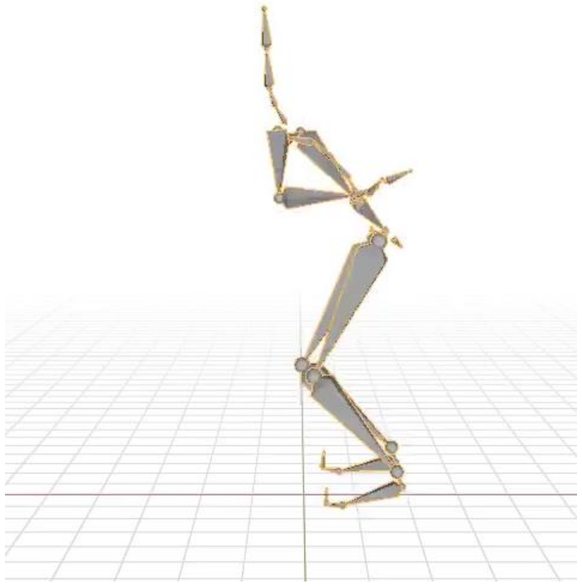


Ablation Studies

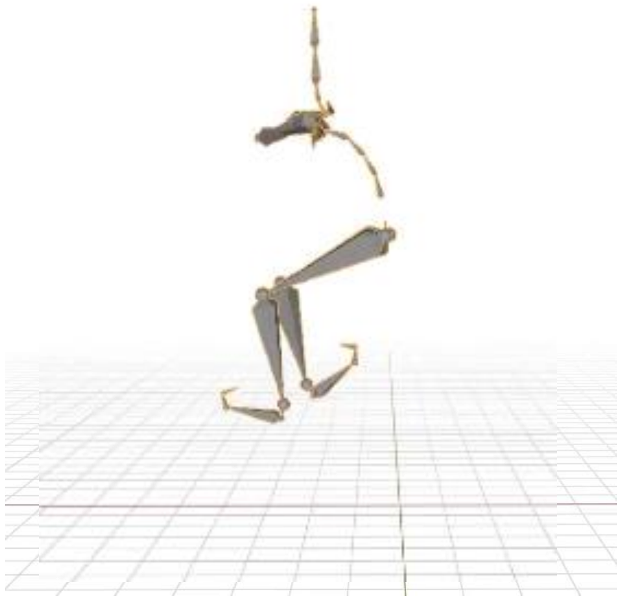
No cycle loss



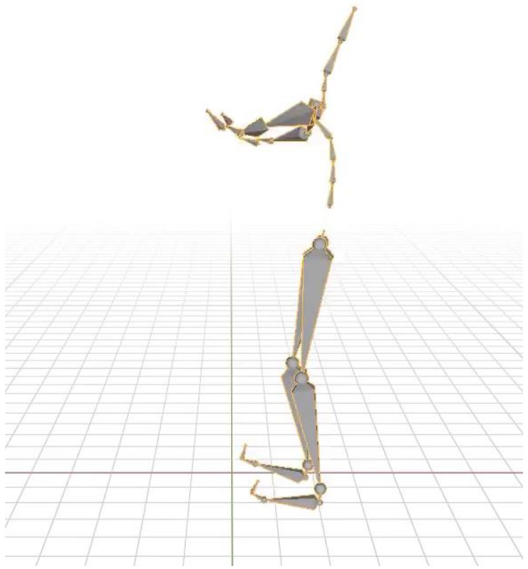
No coherence loss



With transition loss

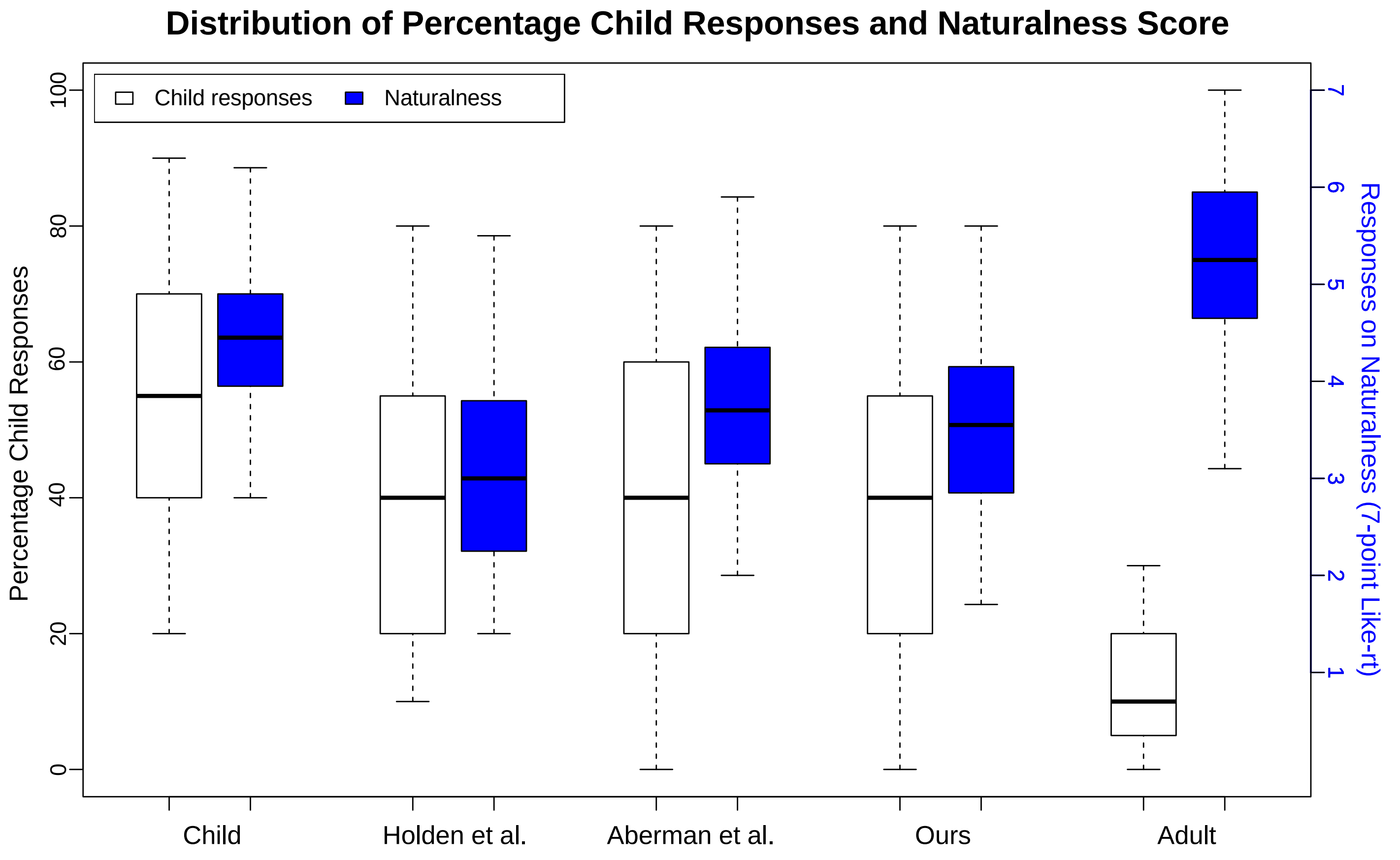


Overall loss
advesarial+cycle+coherence



Perceptual Study

- Point light display of five conditions: child, adult, Aberman, Holden, ours
- 41 participants
- Does this motion belong to a Child or an Adult? (Child/Adult)
- Indicate the naturalness of the motion on a 7-point Likert scale.



Conclusion

- We have presented a method that allows adult2child style transfer,
- We have introduced two additional losses to condition the network, temporal coherency loss, and transition loss.
- The use of motion words helps the network to learn both the spatial and temporal information about motions.

Future Work

- Remove foot sliding/skating by adding constraints (inverse kinematics).
- Investigate mechanisms to change the sequence length and allow smooth blending.
- CycleGAN introduce noise in the output (unexpected angle). Explore additional constraints to reduce jitters.

Code download (in preparation): https://gitlab.com/jainlab/cyclegan-1-master

Dataset download: https://jainlab.cise.ufl.edu/publications.html#Adult2ChildCycleGAN

Thank you!

Yuzhu Dong (looking for an industry research position!)
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